**History of Space, Part 2, *The 1940’s and 1950’s***

**Underlined text students responsible for; non-underlined text supplementary info.**

**PowerPoint color coding – gold general info, red Russia, green Germany, blue America.**

**Slide 1-3**

**(Info)** January **1945** and the war is over for Germany. August 1945 Japan learns of America’s nuclear capability when the U.S. ends WWII through nuclear force at Nagasaki and Hiroshima. At the end of the war, Wernher von Braun was surrendering to the U.S. army and was being snuck out with his missile technology. Glushko and Korolev were also present when Peenemunde was captured and transferred rocket scientist and technologies to help strengthen Russia’s missile program. In May of 1945, approx. 200 German scientists were at the Army’s Ft Bliss Base in El Paso, Texas as prisoners of peace.

**Slide 4-5**

**(USA)** The WAC Corporal was America’s first high-altitude, free-flight, sounding rocket. The WAC Corporal was soon replaced with the Aerobee free-flight sounding rocket. The Aerobee arose when the Applied Physics Lab of Johns Hopkins University assigned Dr James Van Allen the task of surveying the nation’s sounding rocket needs and it was recommended that the WAC corporal evolve into something more substantial. Conceived from Navy design and built by Aerojet the Aerobee used hypergolic liquids like the WAC. Aerobee was a free flight vehicle with three fins that created induced spin. The Aerobee could loft a 150-lb payload to over 80-miles. First flights were in **1947**. There were many versions of the Aerobee: standard, Hi, 150, 150A, 300, and the 350. In **1957** the 350 was the Cadillac of sounding rockets. The 350 was 22” in dia. and boosted by a Nike-Ajax anti-aircraft missile. Its four engines were adapted from the 150A and it was designed to loft large astronomical instruments above the atmosphere. It would loft a 150-lb payload to 300-miles or 1000-lb payload 150-miles. In 1965, the first fully fueled aerobe was ready to fly. The engine burned for 52.7 seconds and the rocket coasted to 232-miles. The last Aerobee flew in May of **1984**.

**Slide 6-24**

**(USA)** Shortly before the war’s end, the U.S. Army did realize it was lagging behind in missile development, and on November 15, **1944** Project Hermes was initiated. The General Electric Company was hired to study and to test any missile technology that is acquired from Germany/WWII. Between 1946 and 1951, sixty-seven captured German V-2’s were flown experimentally at WSMR – originally designated the White Sands Proving Grounds. Due to the V-2 being designed for a 2,000-lb warhead, and the fact the Army would not be testing these vehicles with warheads, the early tests were conducted with sandbags to support the stability of the vehicle. In time, the Army realized valuable research equipment could be placed in the vehicle nosecone that could accurately study the flight and the atmosphere. Some notable flights included test #12 carrying the sun’s ultraviolet intensity. The study discovered that above 15-miles the ultraviolet output jumped up in intensity….the study discovered the earth’s ozone layer. Test #56 carried photographic equipment that photographed the earth from the edge of space – stimulating the weather service into viewing the atmosphere from above.

**Slide 25-27**

**(USA)** The Hermes project allowed for America’s best engineering companies to leapfrog to technologies evolved from Goddard’s work. These companies played an enormous role in America’s space program by developing large liquid-propelled engines, exploring and documenting the earth’s atmosphere, and testing man in space by launching biological payloads. One of the studies was the Albert flights. These were the first studies to see if man could withstand space and the g-loads of flight. Albert I did not survive the launch sequence (suffocation). Albert II had a better designed capsule, his heart rate was recorded to a peak altitude of 83-miles, but the rocket crashed. Albert III and IV had the same fate – III’s rocket exploded three miles up, and IV’s rocket crashed. The final biological payload was a mouse…launched in 1950; the reaction to weightlessness was recorded on a video camera. Though the vehicle crashed and the mouse was lost, the camera survived. Designs and testing was soon taking place with vehicles of interest that were arising from the V-2 technology being investigated.

**Slide 28-29**

**(USA)** Additional companies were involved in technological transfers of information from the Hermes Project and were taking opportunities to begin their own designs and testings. Such companies were: Thiokol, Glenn L. Martin Company, North American Aviation, and also the Air Force and Navy. Vehicles such as the: Hermes A-1 = a surface to air missile capable of about a 38 mile range; and the Hermes RV-A-10 = a solid propelled vehicle study that included **hybrid technology** and evolved to today’s SRB’s. (Not only was roofing tar used as a fuel, but this is when HTPB was discovered and begun testing.) The Hermes II = a Mach 3 ramjet, our first supersonic cruise missile; and most importantly the C-1. Additional flight testing included the Bumper configuration: a WAC Corporal second staged on the top of a V-2. There were eight of these tests. In Feb of **1949** a WAC set a long standing record of attaining an altitude of 244-miles after being boosted by a V-2. The WAC’s were also tested horizontally while the booster was guided parallel to the earth. The vehicle was recorded with velocities around 3,270 mph. The high velocity tests, at horizontal angles, required the Hermes program to locate other ranges that could accommodate such distances. Cape Canaveral was such a place. Mosquito infested swamps and sand dunes, the east coast of Fla. soon would begin to witness test flights that continue today – now called NASA’s Cape Kennedy. Nevertheless, it was obvious that America was beginning to realize the importance of powerful rockets.

**Slide 30**

**(USA)** In **1946**, Convair was contracted by the Air Force to study ICBM. What started the development was the MX-774. The MX-774 used both monocoque and balloon technology…balloon technology incorporated a thinning of the tank walls to where the walls could not stand the forces of flight alone, but relied on pressurization to give them strength. The propulsion system was a spinoff of Reaction Motors Bell X-1 motor. The motor was also gimbaled. Though Goddard had played with the concept years before, in secrecy, this was the first vehicle incorporating gimbaled flight. First tested by Convair in **1947**.

**Slide 31**

**(USA)** By end of WWII the Naval Research Lab was looking to advance WAC and Aerobee. Learning from V-2 technology, and using understanding of the Aerobee, the U.S. Navy develops the Viking sounding rocket. Glenn L. Martin develops the airframe while the propulsion system is developed by Reaction Motors. Like the V-2, the Viking burned Lox and alcohol. In addition, the Viking incorporated gimbled flight. Between **1949-1954** 12 vehicles were tested. The Viking 4 was launched from air craft carrier. The Viking became obsolete, mainly by Aerobee, because of the vehicle’s high expense. Though short-lived, it has it’s place in the lineage of America’s race for space.

**Slide 32-35**

**(USA)** The Hermes II Mach-3 vehicle really excited the military concerning ground to ground cruise missiles. Warheads placed on targets without the ability of being intercepted and no need to leave the atmosphere – something requiring large launch vehicles. In December **1945**, North American Aviation submitted a proposal to the Air Force to continue German V-2 missile research. North American proposed a three stage effort: first add wings to a V-2, then substitute a turbojet-ramjet powerplant for the German rocket engine, and finally couple this missile with a booster rocket for intercontinental range – the Navaho Project was born. TheUSAF saw the Navaho project as a leap forward in the state of the art of missile technology. The Navaho required new technology that resulted in a complex missile. For example, aerodynamic heating demanded new materials. North American used titanium alloys, much stronger than aluminum and yet 40 percent lighter than steel, as well as precious and rare metals at contact points on much of the electrical gear. Other untested technology and areas of risk included the canard configuration, ramjets, guidance, and the massive rocket booster – based on the original V-2 but much larger. Although the Navaho did not get into service, some of its components did. The Redstone used the rocket engine concept, and the Thor and the Atlas adapted the engine – rockets you will soon be learning about.

**Slide 36-48 (USA)** The C-1, mentioned previously, was one of the culminations of the Hermes Program; and could be considered a ‘grandfather’ of today’s ballistic missiles. It started on the drawing board in **1946** with Wernher von Braun’s team and was designed to carry a warhead 500-mile. Like the V-2, the C-1 burned lox and alcohol and used exhaust vanes for guidance. The motor was an adapted NAA 75-110 rocket booster from the Navaho program (which was based on the original V-2 motor). The C-1 showed better capabilities than other SRBM’s by incorporating a separating warhead that possessed its own guidance. First tested in **1953**, the C-1 SRBM was based in Germany by **1958.** Though it would be replaced by the Pershing ICBM, the C-1 has good place in America’s space race history. In **1951**, the paperclip group moved to the Army’s Redstone Arsenal in Huntsville, Alabama. The C-1 is then renamed the Redstone missile. In 1954 von Braun proposes putting up a satellite for the U.S. during the International Geophysical Year (IGY). Von Braun was told no, and in **1955** the Navy was given the Vanguard project to get America’s first satellite up. The Redstone becomes the Jupiter C when it is given a second stage that is a ‘bucket’ of 11 solid ‘baby’ sergeants motors; and, a third stage of three baby sergeants. This three stage, or composite – the reason for C in Jupiter C, was designed to test reentry vehicles for warheads coming in from outside the atmosphere. The first successful reentry test was in Aug **1957**.

**Slide 49-70**

**(USSR)** Russia Post Peenemunde – Starting Oct 1947 – the Russians began a program, similar to the Hermes Project but led by Korolev, to study and better the existing 20 V-2’s they brought from Germany (compared to 100 brought to WSPG). The first vehicle developed from this program was the R-1. Similar to America’s MX-774. Glushko redesigned the German V-2 motor (RD-100) to produce 25% more thrust and allow the warhead to increase to 1.2 tons; or the distance to increase with the standard one-ton warhead. Two series of vehicles spun off from this initial study: the MR-12 sounding rocket – a sounding rocket used similar to America’s Aerobee but developed for the govt/military; and, the V-1-A and V-1-B investigative/research rockets. These later vehicles were multitask/multipod vehicles allowing quicker atmospheric understanding by allowing more research equipment aboard each flight. The R-1 evolved into the R-2 (SS-2) in the early 1950’s; it was capable of lofting 1.5 tons to 370 miles. Similar to America’s Viking. It too was powered by a Glushko lox/alcohol motor and it too had the V-2-A spin-off that studied flight and the atmosphere through the 1950’s. The R-5 (SS-3) evolved from the R-2 and V-2-A. This vehicle resembled the C-1/Redstone in size and function. By 1957 was the R-11….today’s SCUD missile. The most important vehicle of R-series was the **R-7** (SS-6/Sapwood/Shyster). The R-7 was the first true ICBM. Designed in defense of a shore range ballistic missile (SRBM), the Redstone. Largest missile developed by either country…much larger than the C-1/Redstone. Large size due to a design by Korolev to loft primitive nuclear warhead that were very large at the time. Korolev clustered sixteen of Glusko’s RD-107’s around four of his 108’s. Total of 20 combustion chambers; and 12 additional vernier motors around the periphery (guidance). The 700,000-lb R-7 rocket required strong propulsion. However, Glushko never did advance toward large motors. Instead, he clustered his successful motors together to achieve the needed thrust levels. Each cluster had its own fuel and oxygen tanks/pumps. Staging was accomplished by strapping on four boosters, with four clustered 107’s and two vernier motors, around an upper stage of four clustered 108’s with four vernier motors. Produced 1.08 million-lbf of thrust. Two-minutes into the flight strap-ons were blown off. It was now realized, with the power of this vehicle, the Russians could place a nuclear warhead anywhere on earth. They proved this **4 October 1957** when they beat the U.S. by placing Sputnik 1, a 22” diameter 184-lb sphere, into orbit. Something von Braun proposed in 1954 and could have successfully accomplished in 1956. The Sputnik 1 transmitted on the same megahertz cycle as the world’s HAM radio operators. Russia strongly applauded by the world for its technology, something America had mocked.

**Slide 71-76**

**(USA)** As mentioned previously, von Braun and the paperclip/Huntsville team were held back from putting up a satellite since the administration wanted an unknown group, preferably civilian; or at least, American. The project was given to the Navy and was called the Vanguard project. The Vanguard was to get America’s satellite up for the IGY. The Navy was given von Braun’s proposal. The original satellite was the TV-3…a 3.25-lb grapefruit sized vehicle. The vehicle’s configuration used a Viking rocket as the 1st stage, the 2nd stage was an Aerobee Hi, and the 3rd was a small solid. The first test was in 1957…failure.

**Slide 77-84**

**(USA)** With the Vanguard failure, von Braun’s Huntsville team was given the chance to get up a satellite…they did it within 90-days. They had been able to prepare for the test while they were testing re-entry vehicles. Von Braun knew this would keep them in the game. Now, by adding a 4th stage to the Jupiter C, and putting on top the Explorer 1 satellite, designed by Dr.van Allen and built by the Jet Propulsion Lab, the Jupiter C was renamed the Juno 1…administration didn’t want it to be thought of as a SRBM. The Explorer 1 was placed in orbit Jan 31 1958.

**NOTE: Please notice that information is beginning to appear more frequently on the slides.**

**Slide 85**

**(USSR)** At this time, consider Russia had successfully tested a nuclear bomb in 1949…and was continuing to better the bomb…stronger and lighter. With Sputnik they proved they could probably place a nuke on any city in the world. With the race for the satellites, not only had the space race begun, but so had the cold war.

**Slide 86**

**(Info)** Image of Von Braun and Oberth (German Team) and Heads of WSPG and paperclip project (American Team)….the creators of C-1/Redstone and team that put up first satellite.

**Slide 87-91**

**(Info)** Don’t forget that Chuck Yeager, in the Bell X-1, the first of our experimental transonic vehicles, broke the sound barrier using the 6000-C4 motor from Reaction Motors.

**Slide 92**

**(USA/USSR)** In conclusion for this set of notes, this slide compares/shows where Russia and America are at the start of the space race.

**Slide 93**

**(Info)** Rocket Geneology, notice the V-2 derivatives and the WAC corporal. You can see how the V-2 and C-1 are considered the grandfather of today’s heavy lift rockets.

**NOTE: Beyond slide 93 all information will be found on the slides with no need to refer to notes.**